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BUREAU OF LAND MANAGEMENT

ROSWELL DISTRICT

Vegetative Description and Analysis from Literature Reviews for Riparian Zone Vegetative Aspect In The Roswell District Bureau of Land Management

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I. Introduction

The main riparian zone in the Roswell District, 06, runs parallel to the Pecos River and varies in width from a few hundred feet up to a mile or two on either side of the river. This riparian zone is also found along numerous major draws that run into the Pecos River. The Pecos River and draws are dominated by Populus, Salix and/or Tamarix tree species and other hydro and halophillic plants in the Roswell District.

The head waters of the Pecos River originate in the Sangre de Cristo mountains around Las Begas, New Mexico. This river is the primary source of drainage for the east central and southwestern portions of New Mexico (Sheridan 1975).

Outside of the free water, the importance of this vegetative type for grazing purposes is negligible; it's major role is it's influence upon the numerous wildlife species that are directly or indirectly dependent upon the nesting, brooding, rearing, and escape cover which it provides along with the free water, which is available year round in most places.

In this paper the riparian zone will encompass those areas where by the flora and fauna are directly dependent upon or influenced by the free standing or moving water and are influenced by the salts in the upper horizon.

Because of the lack of knowledge concerning the influence of grazing upon the riparian resource along the Pecos River, most of the information contained in this report will be inferred from

studies done in other parts of the county.

II. Physical Description

A. Vegetative Composition

Following is a list of the more common plants that may occur in the riparian zone. Although the list is not complete it comprizes 60 to 70% of the vegetation found in this community. All common and scientific names are from Correll and Johnston (1970) with the date for flower and seed production by the grasses from Pohl (1968).

Key: I= increaser; D= decreaser; P= perennial; A= annual

Common Name	Scientific Name	Period to Flower and Seed Production
Black grama (P,D)	Bouteloua eriopoda	July - Sept.
Side-oats grama (P,D)	Bouteloua curtipendula	June - Sept.
Blue grama (P,D)	Bouteloua gracilis	June - Oct.
Little bluestem (P,D)	Schizachyrium scoparium	Aug - Oct.
Bush muhly	Muhlenbergia porteri	July - Sept.
Sand muhly (P,)	Muhlenbergia arenicola	
Sand dropseed (P,I)	Sporobolus cryptandrus	July - Oct.
Alkali sacaton (P,I)	Sporobolus airoides	June - Sept.
Giant sacaton (P,)	Sporobolus giganteus	July - Oct.
Inland saltgrass (P,I)	Distichlis stricta	April - Sept.
Tobosa (P,I)	Hilaria mutica	June - Aug.
Vine-mesquite (P,I)	Panicum obtusum	June - Sept.
Three-awns (P,I)	Aristida spp.	
Burrograss (P,I)	Scleropogon brevifolius	June - Sept.
Cane bluestem (P,D)	Andropogon barbinodis	June - Sept.
Buffalograss (P,I)	Buchloe dactyloides	Mar. - Sept.
Sedge's		
Rushes		
Muskgrass	Chara vulgaris	
Cat-tail (P,)	Typha sp.	
Horsetail	Equisetum sp.	
	FORBS	
Pepperweed (A,I)	Lepidium densiflorum	Spring-Summer
Buffalo bur (A,I)	Solanum rostratum	Spring-Summer
Silverleaf nightshade (A,I)	Solanum elaeagnifolium	Spring-Summer
Rush-pea (A,I)	Hoffmanseggia sp.	Spring-Summer
Loco-weed (A,I)	Astragalas sp.	Spring-Summer
Bladder-pod (A,I)	Lesquerella gordoni	Spring-Summer
Globe mallow (A,I)	Sphaeralcea sp.	Spring-Summer
(A,I)	Cryptantha sp.	Spring-Summer
Russian thistle (A,I)	Salsola Kali	Spring-Summer
Threadleaf groundsel (P,I)	Senecio sp.	Spring-Summer
Seepweed	Sueda sp.	Spring-Summer
	SHRUBS	
Javelina bush	Microrhamnus or Condlia ericoides	
Sand sage	Artemisia filifolia	
Broomweed	Xanthocephalum spp.	
Mesquite	Prosopis velutina	
Four-wing saltbush	Atriplex canescens	
Salt cedar	Tamarisk sp.	

Common Name	Scientific Name	Period to Flower and Seed Production
Pickle-weed	Allenrolfea occidentalis	
Seepwillow baccharis	Baccharis glutinosa	
Fremont cottonwood	Populus fremontii	
Eastern cottonwood	Populus deltoides	
Goldenrod	Solidago sp.	

B. Desirable Forage Shrubs

Following is a list of the desirable forage shrubs, the season(s) at which these are preferred, the big game animals that may utilize them, and for the Populus species the stage in their ecesis at which they are available. Information taken from Martin et al (1961).

1. Sand sage; mule deer, 5 - 10% of its diet during the winter; antelope, 25 - 50% of its diet during the summer, fall and winter.
2. Four-wing saltbush; antelope, 5 - 10% of their diet during the winter; livestock year round especially winter; mule deer, year round.
3. Salt cedar; cattle, 51 - 63% of the new sprouts during the summer, (Gary 1960).
4. Cottonwood; mule deer, 5 - 10% of their diet while saplings are still within reach of the animal; cattle same amount for usage.

C. Poisonous or Noxious Plants and Season (U.S. Dept. Agri. 1968)

1. Buffalow bur (mid to late summer)

2. Silverleaf nightshade (summer)

3. Loco weed (Spring)

4. Russian Thistle (spring and summer in mature stage)

5. Threadleaf groundsel (year round esp. spring and summer)

6. Broomwedd (spring and winter)

7. Goldenrod (spring and summer)

D. Edaphic Factors

1. Soil

The classification of a number of the soils along the Pecos River fall under the general heading of halomorphic. Which, according to Buckman and Brady (1972), is any soil developed under imperfect drainage conditions in arid regions and characterized by abnormal salt concentrations in the upper horizons. These soils may be broken down into saline, saline-sodic, or sodic soils based upon their cation exchange capacity (CEC) and their ph. while the riparian community is associated with these halomorphic soils, the community is not restricted to them.

According to the SCS and Chugg (1971) the dominate soil association throughout the riparian zone is that of the Arno-Harkey-Anthony association. This association is found throughout the flood plains and adjacent

areas of the Pecos River and is characterized by deep, nearly level soils of calcareous alluvial origin. The Arno series is the dominate soil with the Harkey and Anthony series making up about equal proportions throughout the area. The Pima series is also present in this vegetative type but is of little significance.

a. Arno Series

These calcareous to moderately strong saline soils occur on the flood plains of the Pecos River. The water table is usually below six feet. The surface layer consists of light reddish-brown to reddish-brown silty clay loam. Because of leaching from the surface horizon, finely divided gypsum crystals are concentrated at about 24 inches.

b. Harkey Series

This series is developed in mixed alluvium along low terraces on flood plains of major streams. The water table is less than five feet for part of the year. The surface layer consists of brown very fine sandy loam nine inches thick. They are moderately dark in character, well-drained, strongly calcareous soils that are free of

salts except along Lake McMillan and the Pecos River.

c. Anthony Series

The genesis of this series is from stratified alluvium derived from crystalline and sedimentary rocks. It occurs along the flood plains and low terraces of the Pecos River and the southern part of Lake McMillan. This series surface layer is a pale brown, sandy loam, about six inches deep.

2. Physiography and Erosion

a. Physiography

The descriptive interpretation or geomorphology of the riparian community can be broken down into alluvial and karst topographic features. The alluvial topography is the land counterpart to a delta. It is formed when sediments move from a steep to a flatter gradient and then suddenly losing their transporting power with deposition occurring at that point. This feature is characteristic, but not confined, to arid and semiarid water ways. The karst topography is a feature of those areas underlain by soft strata of limestone,

gypsum, and sandstone and is characterized by sink holes and streamless valleys. It is developed by surface and underground water acting upon the previously mentioned material, carrying it away in solution and allowing the overlying strata to "sink" down. This feature is not restricted to arid and semiarid areas (leet and Judson 1954).

b. Erosion

The Arno soils lie in the flood plain of the Pecos River and are subject to periodic inundation by flood water in the spring. Because of this annual occurrence there is a cyclic removal and deposition of material associated with this soil. Because of this turbulent flow of water, in the spring, under the stream bed embankment, precipitous drops are created within this series. The Harkey soils, prevailing in the draws and higher, flat, terraces, are subjected to slight wind and water erosion when plant cover is removed. The Anthony soils distinguished by their sandy nature, and hummocky and billowy relief,

are subjugated to drifting sand causing severe wind erosion (Chugg 1971; U.S. Dept. of the Inter., Bureau of Reclamation 1975).

III. Effects of Abiotic Factors on Vegetation

A. Temperature and Growing Season

The mean maximum and minimum temperatures for the Roswell District are 20.5°C (75°F) and 4.5°C (44°F), respectively. The hottest months are July and August with the coldest months being December and January. The freeze free period last six months from late April to late October (215 days), corresponding to the period of growth in the Roswell area. April 6 and October 31 are the first and last dates for a 0°C (32°F) reading in the Roswell District (Maker 1971).

Because of the effects of temperature on chemical and physiological rates, a minimum termperature must be reached and maintained to promote seed germination and root growth (Weaver and Clements, 1938, p. 223). Once this critical temperature has been reached there is a doubling of the reaction velocity, by the plant, for each -4.5°C (18°F) temperature increase up to a minimum depending upon the plant in question. The activity and growth of the plant, according to Weaver and Clements (1938), is greatly dependent upon it receiving the required amount of heat, for a certain period of time, during a certain period.

Because of the preponderance of halophytes (salt loving plants) associated with the riparian vegetation, in the riparian community, they would be expected to be less susceptible to frost damage. This is because of the presence of solutes or salts, Na, Cl, Ca in the cell sap. These solutes increase the osmotic pressure within the protoplasm, thus lowering the point at which the plant will freeze (Gail, 1926; Lewis and Tuttle, 1920). This characteristic is vital because of the effects that a late freeze, or an "interruption", according to Salisbury (1963) will inhibit the development of the plant by removing water from the cell protoplasm with the subsequent formation of ice crystals in the intercellular spaces and a precipitation of proteins within the cell proper (Sakai and Yoshida, 1967). This freeze hardiness is also enhanced in the spring, in the apical meristems, by the production of proteins and other solutes in the leaves, moving along a source (leaves) to sink (growing points) gradient.

Because of the free standing perennial water associated with the riparian zone the affects of drought are not as severe as it may be on the other vegetative communities.

This is especially true for phreatophytic shrubs and trees whose root systems consist of both fiberous and tap organs (Weaver and Clements, 1938; U.S. Dept. of the Inter., Bureau of Rec., 1975).

B. Precipitation

There are two main source locations of precipitation over the Roswell District. The major source originates from over the Gulf of Mexico depositing three-fourth's of the annual precipitation, 25 cm (10 in.) from May through October. The remainder of moisture, 7.5 cm (3 in.) originates from over the Pacific, being deposited mainly in the form of snow, from November through April (Mkaer 1971).

Because of the free water source from the Pecos River, for the riparian plants, the effects of drought on the phenological development of the riparian plants is not as dramatic as on the phenology of the other semi-desert vegetative types.

The precipitation in the spring and late summer can influence the vegetation by creating periodic flooding of the flood plain during this period. This higher than average flow rate can be expected four years out of five,

with the lower than average and average flow rates ocurring every fifth or one year out of ten (Hale, et al, 1965). With this inundation of water vegetative zonations are created that are based upon the tolerence of the species to flooding and soil salt concentrations (Busby and Schuster, 1971). For instance, species such as inland saltgrass, salt cedar, alkali sacatone, and cottonwood are much more tolerant to this annual occurrence than sand dropseed, black grama, and mesquite. This subject of the influence of water levels and salt concentrations will be dealt with in the section under physiology.

Because of the influence of the water level on the vegetative zonation, a prolonged drought, two or more years in a row, coupled with the draw down affects of irrigation, can cause a increment of plants, such as salt cedar, into areas that are vacant of any vegetation and have high concentrations of salts in the upper soil horizons (Busby and Schuster 1971). The presence of the extensive subterranean drainage into the cavernous limestone and gypsum formation in the Pecos River Basin (U.S. Dept. of the Inter., Bureau of Reclamation 1975).

Conversely a high prolonged water level, because of heavy rains, can cause a reduction of plant composition and

density because of a lack of oxygen and the attraction of salts into the newly flooded area creating physiological stress upon these plants not used to this high salt concentration. All this causes a reduction in the productive capacity of the area in question (Robel 1962).

C. Wind and Water Losses

The influence of wind upon the riparian vegetation, because of the free water in the Pecos River, is not as severe in relation to transpiration as it is upon other vegetative types in the Roswell District. Although during the summer when the river is at a low level, due to drainage into aquifers and irrigation, physiological drought, because of the high osmatic pressures in the soil due to the salts, may occur on the periphery of the riparian zone (Weaver and Clements, 1938).

IV. Successional Changes

Because of the annual action of water during the spring and summer months, in flooding and the subsequent removal of plants along the flood palin, this area may be classified in a secondard successional stage. This classification is applied to those communities where "development is proceeding in an area from which a community was removed" (Weaver and Clements, 1938).

This type of succession may occur rapidly because the sand bars and islands provide a very condusive medium for germination to those wind and water transported plant germinals (cottonwood, Sulix).

Succession along river banks of the Mississippi, according to Danbenmire (1968), is in its oldest sere stage on those terraces furthest from the river. The pioneer stage in this instance is characterized by annual weeds with shrubs and trees such as seepwillow, Salix and Populus, also found in this seral stage; the latter influencing the development of the riparian ecosystem by their canopy cover. Nielson (1953) with his work on the revegetation of alkali flood plains along the Platte River in Nebraska concluded that the riparian community, if undisturbed, would obtain the "climax" state in 20-30 years and be dominated by inland saltgrass and sand dropseed.

Because of the presence of Tamarix in the riparian community the areas where this species is present, may be classified as in a subclimax state. This is because of the influence that Tamarix, a native of the Mediterranean area, plays in preventing the riparian community from reaching it's "climax" state (weaver and Clements, 1938). Because Tamarix has been present in the riparian community for over 100 years (Valentine, 1971; U.S. Dept of the Inter., Bureau of Reclamation, 1975) and that this community

may have, during this period become readjusted to the presence of this species, the riparian community could be classified in a "climax" condition, relative to the present day environmental conditions (*Tamarix*, irrigation).

V. Effects of Grazing

A. Effects of No Grazing

The influence of no grazing upon the riparian habitat is three fold: (1) its impact upon the vegetation; (2) upon the watershed; and (3) upon the wildlife habitat. Because these three components are so interrelated they will be considered as one with no attempt to separate the cause-effect of livestock on them.

Results on the effects of the complete resting of riparian habitat in various parts of the country concluded that if a riparian community were rested for five years or more such changes as vegetative density and composition; waterfowl nesting habitat; aquatic habitat; and predator cover would increase (Gjersing, 1975; Lusby, 1970; National Academy of Sciences, 1970).

Lusby (1970) with his work concerning grazing vs. nongrazing, in southcentral Colorado, concluded that runoff and sediment yield was significatly reduced, 30 and 45% respectively, after only two complete years of complete rest

(Figure 1). This reduction in sediment yield can play a major role in spawning grounds and eutrophication of the many perennial pools along the Pecos River (Odum, 1971; National Academy of Sciences, 1971).

B. Effects of Grazing

The impact that livestock have on riparian vegetation is influenced by many components such as: (1) duration; (2) frequency; (3) intensity; (4) access; and (5) season (Stoddard 1975).

Because of the free water associated with the riparian community uncontrolled livestock grazing can affect the vegetation, soil, watershed, and the aquatic and terrestial wildlife habitat (Lull, 1959; Lakemoen, 1973; Tuocott, 1975). The riparian community is subject to change "because of the preference of cows for the more level lands near water and the greater production there of succulent vegetation (Harvey et al, 1971; Stoddard, 1975). These same authors mentioned that the more frequent and intense the grazing the less the overhanging vegetation (i.e., *Salix*, *Populus*, *Tamarix*) will be able to shade the water. A reduction in overhanging vegetation can also be attributable to soil compaction, preventing seed germination, and the failure to allow the dead and dying shrubs and trees to be replaced. Without this sahde, the temperature of the water would increase, lowering

the dissolved oxygen thus making the water less likely to support aerobic (oxygen demanding) life (Salisburty and Ross, 1969; Odum, 1971).

Ranzi (1963) noted a decrease in water intake into the soil profile, with an increase in stocking rate and a marked change in vegetative composition on grazed vs. nongrazed watersheds. The difference between the water intake rates on the moderately grazed vs. the heavily grazed, and the moderately grazed vs. the ungrazed were 1.6 and 1.8 times greater, respectively.

Tuocott (1975) working out of the BLM Nevada State Office, through the use of a questionnaire, found that livestock grazing was having an adverse effect upon riparian habitat, especially in desert areas. This was because of the dependency of game and non-game birds, amphibians, reptiles and mammals upon the water source and cover which are offered by the riparian vegetation, exposed the stream to pollution, increased water temperature, sediment production, and changed the chemical composition of the stream environment.

Gjersing (1975) working with rotation grazing systems and waterfowl production in Montana found that a rest-rotation system actually produced more riparian vegetation which resulted in additional nesting and/or brood rearing security;

if the periods of rest and grazing were properly correlated with the periods of nesting and brood rearing. The two most important factors that Gjersing brought out were (1) allow the pasture to rest after end of earliest grazing period (spring or early summer) and (2) delay grazing of pastures with residual cover (from the previous year) until incubation is completed on most nests; in the Roswell District this incubation is usually over as of mid to late July. Bue (1952) demonstrated that year round grazing reduced the nesting cover around stock ponds. He also reported that the shoreline cover, breeding pairs, and broods decreased in proportion to grazing intensity. Bellrose (1961) observed an inverse relationship between population density and the production of young checks. Inference from these findings would imply that with the "correct" rest-rotation grazing system the number of nests would steadily increase to an optimum, with the limiting factor, according to Liebig's "law" of the minimum, being the available nesting area, and hence brood production being a function of the available space for such activities.

Day (1966) observed a secondary affect that grazing would have on waterfowl nesting habitat. His observation was related to predators and the fact that with periodic grazing

the cover available to predators attack cover was significantly reduced so that those losses attributable to predators were reduced.

VI. Physiology of Riparian Floura

Because of the impact of rain on the physiological development of the plants in a semi-desert grass plains ecosystem this factor will receive the main emphasis in this section. Other components in the physiological development of the riparian ecosystem will be those dealing with temperature and soil salinity.

The effects that precipitation plays on warm season plants depends upon the period and duration with which moisture is received during the spring-summer-early fall growing period. (figure 2). For a growing period receiving moisture in the spring, the growth and development is initiated during April and May with a slight slow down in June and July; resuming again in August and peaking out in October. For a growing period with a dry spring, which is common in the Roswell District, growth and development is not initiated until July and August with the peak growing period again occurring in October (Dahl, et al, 1975).

Not only that seasons precipitation but the moisture received that previous year, according to Nelson (1934), has a marked influence upon the general overall condition of the plant. This is

because the healthier the plant is that previous season, due to precipitation and "normal" stocking rates, the better adapted it will be to over-winter and break the winter dormancy producing more tillers that following spring.

The effects of drought and a late from on the general condition of the plant, especially the carbohydrate reserves, may be quite severe. If after the initial green spring green up by the grass plant, which, during this tiem, has be utilizing the stored carbohydrates in it's roots, crown, etc., a drought occurs, the plant will stop all of it's biological growth and differentation, except for it's basic respiration and go into dormancy (Dahl, et al, 1976). Once more favorable conditions for growth resume the plant will have to draw upon its already depleted carbohydrate reserve to produce leaf tissue for the manufacture of glucose and store this as starch or carbohydrates (Hormay, 1970). If the plant's carbohydrate supply has already been depleted from the first green up period, the second green up period, after the drought, may never occur or will be reduced substantially because of the lower carbohydrate supply. This sequence of events not only weakens the plant but allows for the establishment of invaders and increasers.

The effects of continuous, year after year, grazing during the growing season, especially on the bunch grasses, can also cause the same sequence of events mentioned above for drought

(Dahl, et al, 1976). Hormay (1970) dealing with the effects of grazing the plant (Idaho fescue) during the green up period show that the carbohydrate supply is at a low level at this time and with the removal of the leaf tissue the plant would be in a weakened condition by being unable to regenerate enough leaf surface in order to store carbohydrates for that winter's dormancy period. (Figure 3).

The general morphology of the grass plant such as; (1) growth form, (2) ratio of basal nodes to seed heads, and (3) the height and date of apical meristem evaluation will determine whether the grass is an increaser or decreaser (Rechenthin, 1956; Stoddard, 1975).

The general proper use factor for most grasses is 40 to 50% of their total weight (Schamtx, 1971). Although this 40 to 50% use factor is the maximum amount of forage that should be removed, it does not dictate the time at which livestock should be rotated. The rotation periods should be determined more by phenology than by utilization under proper stocking rates. This same author estimates that the proper use factor for shrubs is 60 to 70% of the current years twig growth. This greater utilization factor of shrubs than grasses is because the older twigs and the twigs out of reach of the animals can also produce leaf growth to carry on

on the food manufacturing processes necessary for plant growth seed production, and carbohydrate storage.

The effect that salts in the upper soil profile may have on the plants physiology are similar to that of frost on the plant; that is the salts remove water from the cell's protoplasm thus making the cells water potential more vegetative or conversely the soils water potential more positive (Salisbury and Ross, 1969); this causes the plant to undergo what is termed physiological stress.

Because of the abundance of salts in the horizon certain plants have developed in the area that are able to cope with this alkalinity. These plants are called halophytes and give rise to characteristic zonations that are based upon the plants ability to copy with this condition (Weaver and Clements, 1938, p. 466). These zonations are created due to a couple of reasons: (1) the water potential in the horizon may make it difficult for the plants to obtain water, and (2) specific effects of the ions in the horizon (Salisbury and Ross, 1969, p. 696). A few examples of these halophytes are as follows:

(1) Pickle or iodine weed

(2) Salt cedar

(3) Four-wing saltbush

(4) Seepwillow baccharis

(5) Inland saltgrass

(6) Alkali sacatone

VII. Potential Key Species of Riparian Zone (Gay, Dwyer and Steger, 1970)

A. Sand dropseed, Sprorbolus cryptandrus (Torr.) A. Gray

This erect, tufted, warm-season, perennial bunchgrass is from 43 cm (19 in) to 1220 cm (48 in) tall. It is characterized by a ring of still white hairs at the junction (collar) of the stem and leaf. The leaves are up to 28 cm (12 in) long and become frayed in the wind. The gray to purplish seedhead is often enclosed in the flag leaf.

It occurs primarily in the southern desert and western plateau on sandy and gravelly sites from 924 meters (3000 ft) to 1900 meters (7200 ft).

This specie is sually palatable to cattle and moderately so to sheep. It cures well and furnishes winter feed although it is less palatable when dry. It is an increaser and provides better summer grazing than winter because of its low palatability during the latter season.

B. Inland saltgrass, Distichlis stricta (Torr.) Rydb.

This warm-season, perennial, sodgrass is low growing with scaly creeping rootstocks. The leaves are wiry, usually enrolled and sharp with the seed stalks usually no more than 37.5 cm (15 in) high.

This is a common and ubiquitously occuring grass on salt flats, salty bottom lands, and meadows; seldom found above 1900 meters (6500 ft).

The palatability is usually low to moderate for all

classes of livestock. Because it usually grows in damp places it turns green when other grasses are dry and is best suited for spring and fall grazing.

C. Fourwing Saltbush, Atriplex canescens (Pursh) Nutt

This shrub, also known as chamiza, is grayish-white to pale green throughout the winter. The branches form at ground level and may be up to 1800 cm (6 ft) tall. The plant is dioecious with the seed of the qustallate plant having four conspicuous wings.

This species inhabits the southern and northern deserts and the western plateau. It is quite drought resistant and adapted to diverse soils types, from sandy to saline and alkali soils in the bottomlands.

Fourwing is one of the most preferred shrubs of the southwest. All kinds of livestock, except horses, will graze the leaves, stems, flowers, and seeds. It is considered a valuable component of the habitat for many wildlife species. Prolonged, continuous use of more than 60% of that current years growth will severely weaken and eventually kill this shrub.

VIII. Analysis of Treated Area and Conversion Treatment Considerations

The riparian zone has two main conversion treatments. These

two treatments are mechanical and chemical control. These treatments are aimed at controlling two major shrub species salt cedar and mesquite. Map One indicates riparian zone.

Mechanical control treatments are the more expansive of the two treatments. This treatment is deemed economically feasible because of the amount of water reclaimed for more profitable uses such as agriculture and manufacturing. In agriculture the average value added per acre foot diverted is around forty four dollars. The value for industry of an acre foot of water diverted is estimated at about 212 dollars. Based on conservative estimates one acre foot of water per year can be salvaged from treated acreage. (Pecos River Basin Water Salvage Project Environmental Impact Statement, EIS). There are several acceptable mechanical methods which have been used in phreatophte control. Some of these methods are tree crushing, disk harrowing, bulldozing, root plowing, grubbing, chaining, bursh raking, chopping, rotary mowing and draglining. Revegetation of these treated areas have been carried out in two methods natural and reseeding. Where there is enough native vegetation present to reseed treated area no reseeding is done. In areas with insufficient native vegetation reseeding is conducted according to Management Framework Plans (MFP) decisions.

Some clearing criteria which are considered are: (1) areas with less than 10 percent areal density of phreatophytes will

not be cleared, (2) no control treatments within 5 ft. of fence rows, (3) no control treatments on arroyos, riverbanks, terraces, or depressions with banks steeper than a 1-½:1 slope and higher than 4 feet, (4) no control in areas with high water table which has rendered the ground unstable, (5) no control along banks of tributary draws, arroyos or drains, (6) no controls within a minimum of 30 ft. of existing river channel and natural waterholes unless approval is given, (7) no control on sand dunes where woody plant growth is desirable to controlerosion (Pecos River Basin Water Salvage Project EIS).

Chemical control treatments are less effective than mechanical treatments. Chemical controls are less effective than mechanical treatments. Chemical controls are most effective when applications are timed correctly. The best time for applications are when the plants nutrient reserves are at their lowest points. This is the plants most vulnerable point, and time when control is optimum. (Pecos River Basin Water Salvage Project EIS and Vallentine 1971). There are two methods of applying chemical controls. These are aerial application and ground application. The ground applicator is driven behind a tractor or catepillar with the spray rig mounted on the tractor or catepillar or on a trailer pulled by the tractor or catepillar. The aerial applicators are mounted on the struts of a helicopter or wings of airplane. The following criteria are used for the application of chemicals: (1) the use of invert emulsions to reduce drift, (2) no ground spraying when wind velocity reaches 10 mph, (3) no spraying with-

in one half mile of susceptible crops, (4) no spraying within 50 ft. of any navigable water, (5) no aerial spraying when wind velocity reaches 8 miles per hour, (6) monitoring of streams during spraying season, (7) strict adherence to recommendations and instructions which apply to the chemicals being used, (8) spray with chemicals cleared by the Environmental Protection Agency. (Pecos River Basin Water Salvage Project EIS).

IX. Seeding Consideration

Seeding treatments in the riparian area have been undertaken with limited success. There are several problems which reduce the efficiency of the seeding operation. Climate is the greatest problem. High temperatures and low rainfall contribute to low germination rates. It is difficult in timing the seeding operation before periods of rain because precipitation patterns are difficult to predict. (Pecos River Basin Water Salvage Project EIS and Vallentine 1971). Seeding should be done in late summer for optimum success. The practice of seeding forbs and shrubs which are valuable forage species should be added to the grass seed being planted. Planting equipment necessary for seeding usually consist of a drill planter pulled by a catepillar. The cleared areas usually make a good seed bed. The seeded area should be deferred from grazing for at least one full growing

season and grazed lightly for several years after with constant monitoring of the area to ensure against destruction of seedling establishment.

In areas where there is a good population of forage species present nature revegetation should be allowed to take place. The same rest should be given to the natural revegetation areas.

X. Type Conversion Treatment Recommendations and Cost and Benefits of the Principle Control

There are two major division of conversion treatment considered for the riparian zone. These are mechanical and aerial. The mechanical methods will be discussed in the first part of this section and aerial methods will be discussed in the second part. (1) Tree crushers also known as rotobeaters and shredders knock down and shred small brush and weeds by means of a series of flails attached to horizontal shafts which revolve at high speed. The tree crushers costs run as low as 2 to 5 dollars per acre and as high as 25 to 50 dollars per acre. (Vallentine 1971). (2) Disk harrowing or offset disks are adapted well to dry heavy soils. Disk harrowing works well up to a slope of 30 percent. Once over treatment usually gives a satisfactory kill. Costs in 1967 ranged from 12 to 20 dollars per acre. (3) Bulldozing treatments uproot stands of brush. The cost per acre de-

pends greatly on the density of the brush present. Costs range from 4 dollars per acre for low density brush to 40 dollars per acre for high density brush. (4) Root plowing is a method used where other methods are not effective. Root plowing is used in deep soils where brush species are predominate. Root plowing kills brush species and perennial grasses so root plowing should not be done in areas with good grass stands. Costs for root plowing range from 12 to 25 dollars per acre. (5) Grubbing is similar to root plowing however the grubbing blade is much smaller than the root plow. It is used in clearing small stands or clumps of phreatophyte. It does not destruct habitat as much as root plowing. Costs are similar to root plowing. (6) Chaining costs range from 1.50 to 5 dollars for once over to 3 to 10 dollars per acre for twice over. Chaining is accomplished by dragging a heavy anchor chain weighing 25 to 100 lbs. per foot of chain in a U or J shape behind two crawler tractors across the area being cleared. This method uproots plants and shears trunks near ground level. A greater kill is obtained by the second trip over the area. (7) Brush raking shears small brush and stumps into piles. Rakes have the advantage of permitting the soil to pass between the teeth as they are pushed through the soil, ripping out and pushing brush and stumps into piles or windrows. Costs average 6 dollars per acre. (8) Chopping or rolling brush cutters knock down and shatter trees 6 to 7 feet high and 2 to 4 inches in diameter. The drum of the chopper has

advantages of helicopters are (1) no landing strip required, (2) trees, snags and steep terrain less troublesome, and (3) greater accuracy resulting from slower airspeed and greater maneuverability. Average cost for aerial applications are 6 dollars per acre. Advantages of ground application are (1) adapted to small acreages, (2) no landing strip required, (3) less drifting and less subject to fog and wind, (4) commercial equipment not required, and (5) safer for applicator. Cost for ground applications are generally slightly more expanses than aerial applications but it is still less expanses than mechanical methods. Information for the chemical treatments was taken from (Vallentine 1971) and Pecos River Basin Water Salvage Project Environmental Impact Statement. Based on values of added benefits stated in Section VIII all the above treatments would meet a positive cost-benefit return.

XI. Grazing Treatment Considerations

Of all the vegetative subtypes or aspects in the Roswell District, this is probably the most difficult to determine what is the best applicable method to apply. Because of its proximity to water, and its relative low relief concentration of livestock is going to occur under most any system devised unless it is fenced off and managed separately with "Water Gaps" developed to

allowing watering of animals using non-riparian pastures when the riparian pastures are being deferred to allow for plant physiological requirements.

If phreatophyte control has taken place it is desirable to graze the new young Tamarix heavily to reduce resprouting, but to allow for perennial grasses to increase, deferment is needed.

Perhaps as Gjersing reported, allow grazing in the spring and early summer, then remove livestock from the area and close the gate behind them would be the best control areas. This method will allow for regrowth of the vegetation and provde residual cover for the following spring.

On none treated areas a grazing system which meets the physiological needs of the forage plants should be applied, again, depending on the effects of heavy utilization on the sites, consideration should be given to fencing the entire riparian area, and managing as a separate pasture where utilization can better be controlled and livestock excluded at critical times. In general non-use from grazing one complete year plus one spring out of every 3 years should be adequate to maintain existing plant composition and density. Improvement of condition may require 2 complete growing seasons of non-use including the winter period in between.

The diversity of vegetation, and the variation in composition in the riparian zones makes it extremely crucial to evaluate

each site and develop a grazing system best suited for that site based on location, use, livestock distribution problems, and species composition.

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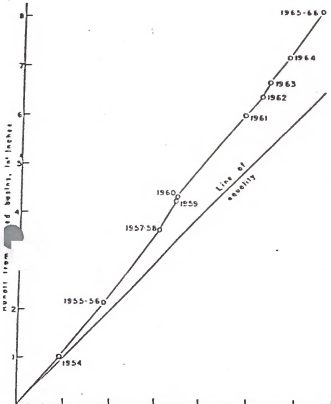
FIGURE ONE



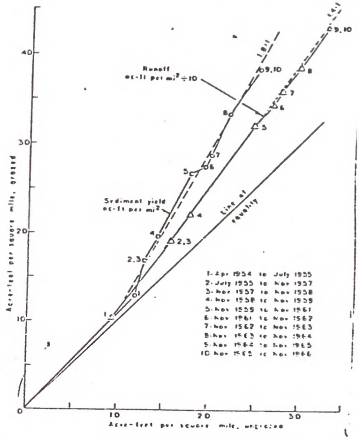
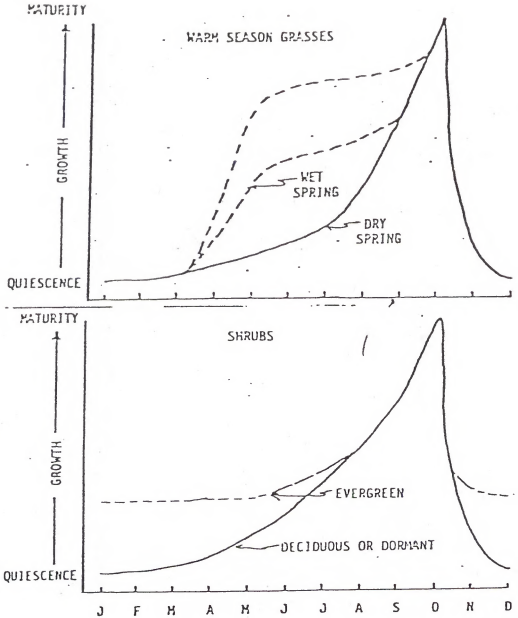


FIG 1. Mass diagrams. ~~Upper~~ (left), runoff in grazed and ungrazed basins at Badger Wash, by years; ~~lower~~ (right), sediment yield and runoff at Badger Wash, by periods.

FIGURE TWO



(Fig. 2 Characteristic Growth curves related to seasonal moisture occurrence)

FIGURE THREE

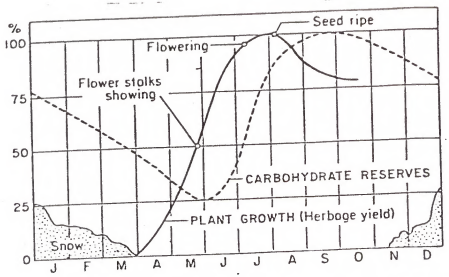
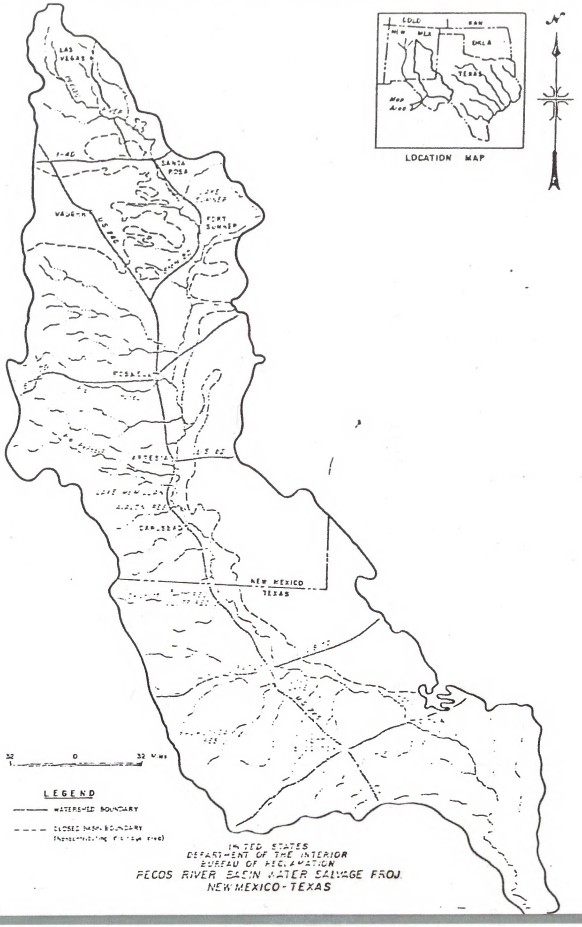


Figure 3.—Trend in carbohydrate reserves in relation to shoot growth. Shoot growth of Idaho fescue and based on data by Hormay and Talbot (1961). Carbohydrate curve, based on data by McCarty and Price (1951), is related to curve of Idaho fescue by plant growth stages.

MAP ONE

GENERAL MAP OF RIPARIAN ZONE
(Pecos River Basin Water Salvage Project EIS)